

# *Red Line/Blue Line Connector Project*

Boston,  
Massachusetts

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Massachusetts Department of Transportation  
Boston, Massachusetts



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## **1.1 Introduction**

The Red Line/Blue Line Connector Project is being undertaken by Massachusetts Department of Transportation (MassDOT, formerly Executive Office of Transportation and Public Works, EOT) and the Massachusetts Bay Transportation Authority (MBTA) to enhance the connectivity of the Red and Blue Lines via an extension of the Blue Line. The project proposes to extend the Blue Line under Cambridge Street to the Charles/MGH Station on the Red Line.

The extension would entail the realignment of the westbound Blue Line track through Bowdoin Station; a new subway tunnel extending under Cambridge Street from Joy Street (where the Blue Line Government Station is located) to Charles Circle (where the Red Line the Charles/MGM Station is located); and a new connection between these lines via a new underground Blue Line Station which would connect to the Red Line Charles/MGM headhouse by a new pedestrian connection between platforms.

Two basic design alternatives are being considered:

- Blue Line extension to Charles/MGH Station with the elimination of the Bowdoin Station; and
- Blue Line extension to Charles/MGH Station with the relocation of the Bowdoin Station.

The design alternatives were further defined in terms of tunnel construction techniques (mined tunnel versus cut and cover). Two design/construction technique alternatives were advanced for further development following a qualitative evaluation, they are:

- Alternative 1 - Blue Line extension to Charles/MGH Station using a mined tunnel construction technique and the elimination of the Bowdoin Station; and
- Alternative 2 - Blue Line extension to Charles/MGH Station using a mined tunnel construction technique and the relocation of the Bowdoin Station.

The Operating Plan Report is a requirement of the Alternatives Analysis Task and will be ultimately incorporated into the Draft Environmental Impact Report.

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## **1.2 Alternative Service Description**

The Blue Line is one of the four rapid transit lines operated by the MBTA. The Blue Line currently operates between Wonderland Station in Revere, Massachusetts to Bowdoin Station in Boston. The Blue Line connects to Green Line at Government Center and the Orange Line at State Street. Today there is no direct connection between the Red Line and the Blue Line; passengers wishing to do so must transfer to either the Orange or Green Lines to make this connection.

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### **1.2.1 Rolling Stock**

The railcars operating on the Blue are unique because they use both third rail and an overhead pantograph to draw propulsion power. Railcars operate using the third rail between Bowdoin and Airport Station where the line is underground. Between Airport Station and Wonderland Station, where the line operates above ground, the overhead pantograph is used. The Blue Line uses #5 East Boston cars by Siemens (these #5 cars are replacing the #4 cars that were previously operated in revenue service). Each car is 48.5 feet wide and just over nine feet high. They have a seating capacity of 35 passengers.

In September 2008, MBTA began operating six-car trains in revenue service on the Blue Line. All Blue Line stations can accommodate the six-car trains except for eastbound platform at Bowdoin Station. Currently, at this station, two cars on eastbound trains must stop in the tunnel and passengers must use door controls on the four cars on the platform. Television monitors are used by motormen to observe door operations.

For the purposes of this operating plan, it is assumed that six-car trains will be used in revenue service on the Blue Line for both alternatives.

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### **1.2.2 Right-of-Way Parameters**

The track configuration for both alternatives is similar with the exception of the exclusion of Bowdoin Station in Alternative 1 and its inclusion in Alternative 2. Under both design alternatives the alignment will be double track for a length of 2,700 feet from the west end of the existing Blue Line Government Center Station platform to the west of the platform at the new, proposed Blue Line Charles/MGH Station.

The new MGH interlocking, a diamond crossover is proposed to be located just to the east of the proposed Blue Line Charles/MGH Station from STA 3+80 to STA 7+00.

The signal system on the Blue Line is an absolute block system with trip stop enforcement. For analysis purposes, speed limits are assumed to be 10 miles per hour (mph) for the first 315 feet along the platform, 15 mph over the Number 8 crossover at MGH interlocking (650 feet including a 300-ft. long train length), 30 mph for the next 900 ft. of basically tangent track, 20 mph for the first curve with its 300-foot radius, and 18 mph for the curve just west of Government Center.

Traction power will be provided by traction power substations fed by 13.8 K volts 3 phase and rectified to 600 volts DC.

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### **1.2.3 Stations**

Alternative 1 proposes eliminating the existing Bowdoin Station and constructing a new underground station below the existing Red Line Charles/MGH Station. The proposed Blue Line Charles/MGH Station would connect to the existing Red Line station via stairways and escalators, allowing passengers to transfer between the two lines.

Alternative 2 proposes relocating the platform of Bowdoin Station while maintaining the existing mezzanine and headhouse. Under this scheme, Bowdoin Station would be able to accommodate six-car trains. Access to the platforms would be made via escalators, elevators and stairway connections. In addition, a new underground station below the existing Red Line Charles/MGH Station would be constructed and connections between the two stations would be made via stairways and escalators.

**Table 1-1 Station Locations by Alternative**

<b>Alternative 1</b>	
<b>Station name</b>	<b>Appropriate project stationing*</b>
Charles/MGH	0+35
Government Center	27+76.47
<b>Alternative 2</b>	
<b>Station name</b>	<b>Appropriate project stationing *</b>
Charles/MGH	0+35
Bowdoin	13+00
Government Center	27+76.47

\* - Station locations are based on track profiles developed for Alternatives 1 and 2.

## 1.2.4 Hours of Operation

It is assumed that the hours of operation on the Blue Line will remain unchanged with the extension. Blue Line service would operate from 5:00 AM to 1:00 AM, weekday and Saturdays; and 6:00 AM to 1:00 AM on Sundays. Presently, Bowdoin Station is closed weekday evenings (after the 6:18 PM departure and the service begins and ends at Government Center). It is assumed that with the extension at MGH, all trains would serve that station.

## 1.2.5 Headways

The headway is the elapsed time between one vehicle and the next traveling in the same direction.

It is our understanding that in September 2009, MBTA began implementing signal improvements to the Blue Line which allow a two-track turnback at Wonderland and increase speeds on the eastbound approach to the Orient Heights Station. These improvements should result in reductions of the actual, effective running times on the Blue Line by eliminating the single-track bottleneck at Wonderland which causes train congestion and backups and their resulting delays. MBTA may elect to utilize these operating enhancements to reduce one-way running times on the Blue Line following the implementation of these improvements and may also wish to operate more frequent service.

For the purposes of this operating analysis, the most current running times and headways that appear on the September 5, 2009 version of the Blue Line Headway Reports were assumed and applied to the extension of the Blue Line. The current scheduled headways by time of day as of September 5, 2009 are presented in the following tables.



**Table 1-2 Wonderland to Bowdoin/Government Center - Westbound**

<i>Wonderland to Bowdoin –Westbound - Weekdays</i>			
Time Period	Number of trips	Frequency	One way run time (minutes)
Early Morning - 5:00 AM to 6:30 AM	14	every 6 to 7 minutes	20
AM Rush - 6:30 AM to 9:00 AM	33	every 4 to 5 minutes	20
Midday 9:00 AM to 3:30 PM	51	every 4 to 11 minutes	19-20
PM Rush 3:30 PM to 6:30 PM <sup>1</sup>	37	every 4 to 5 minutes	19
<b>Wonderland to Government Center-Westbound- Weekdays</b>			
Evening 6:30 PM to 8:00 PM	10	every 9 to 10 minutes	17
Late Night 8:00 PM to Close	25	every 10 to 13 minutes	16-17
<b>Total Trips</b>	<b>170</b>		

**Table 1-3 Bowdoin/Government Center to Wonderland - Eastbound**

<i>Bowdoin to Wonderland –Eastbound - Weekdays</i>			
Time Period	Number of trips	Frequency	One way run time (minutes)
Early Morning - 5:00 AM to 6:30 AM	10	every 6 to 7 minutes	21
AM Rush - 6:30 AM to 9:00 AM	33	every 4 to 5 minutes	21
Midday 9:00 AM to 3:30 PM	57	every 4 to 11 minutes	21-23
PM Rush 3:30 PM to 6:30 PM <sup>2</sup>	39	every 4 to 5 minutes	23
<b>Government Center to Wonderland – Eastbound - Weekdays</b>			
Evening 6:30 PM to 8:00 PM	11	every 7 to 9 minutes	21
Late Night 8:00 PM to Close	27	every 10 to 13 minutes	20
<b>Total Trips</b>	<b>177</b>		

## 1.2.6 Running Times for the Blue Line Extension

Travel time estimates resulting from the extension of the Blue Line were developed for both alternatives using a spreadsheet model taking into account the following assumptions:

<sup>1</sup> Includes 5 "PM Rush" trips from Wonderland to Government Center.

<sup>2</sup> Includes 2 "PM Rush" trips from Government Center to Wonderland

- In order to provide a common basis of comparison for the alternatives, the running times are estimated from the new MGH Station to the Government Center Station.
- The running times are calculated for eastbound trains only under the assumption that the running times westbound will be virtually identical, at least at the present state of project development.
- For analysis purposes, speed limits are assumed to be 10 mph for the first 315 feet along the platform, 18 mph over the Number 8 crossover at MGH interlocking (650 feet including a 300-ft. long train length), 30 mph for the next 900 ft. of basically tangent track, 20 mph for the first curve with its 300-foot radius, and 18 mph for the curve just west of Government Center. In the absence of curve speed information, the first curve's speed has been based on the MBTA Design Criteria assuming the maximum actual and unbalanced superelevation standards.
- Acceleration and braking times and distances are shown in the columns titled "Speed Change - to - Cruise" while the portion of constant speed are shown under the columns labeled "Cruising".
- For Alternative 2, a 20-second allowance has been made for the stop at the new Bowdoin Station; this is included in the segment from Bowdoin to Government Center.
- A Schedule Adjustment factor has been applied to these times to account for train operator reaction time and vehicle performance variations. Given the level of detail at this point in the project's development, 20 percent has been used for this factor.

The net increase in running time for the Blue Line Extension from Government Station to Charles/MGH Station is 2.48 minutes for Alternative 1, and is 4.13 minutes for Alternative 2 (which assumes a relocated station at Bowdoin).

It should be noted that the net increase in round trip running time takes into account the time savings accrued from the elimination of the Bowdoin Loop, that is, under both alternatives, westbound trains will no longer have to travel around the loop to get into position to travel eastbound. This move takes 3.0 minutes according to the July 29, 2009 signaling report. In addition, the layover time at Charles/MGH is assumed to be four minutes.

**Table 1-4 Comparison of Blue Line Extension Running Times  
(Round Trip to Government Center)**

Alternative	One-way Running Time (minutes)	Round Trip Running Time (minutes)	End of Line Time (minutes)	Gross Time From Gov't Ctr (WB) to Gov't Ctr (EB) (minutes)	Net Increase in Round Trip Running Time (minutes)
Existing	N/A	3.00 <sup>3</sup>	3.0	6.0	N/A
Alternative 1	2.24	4.48	4.0	8.48	2.48
Alternative 2	3.06	6.13	4.0	10.13	4.13

Supporting calculations used to develop One-way Running Times for the Blue Line Extension are included in the Appendix.

## 1.2.7 Train Requirements

Based on the most current running times and headways that appear on the September 5, 2009 version of the Blue Line headway report, 13 trains (12 scheduled and one run-as-directed train) are required to provide peak period service.

The peak train requirements are calculated by dividing the cycle time by the peak headway. The following formula is used:

$$N = T/h$$

N = number of trains

T = cycle time (i.e., the time required to complete a round trip, including one-way trip times in both directions and layover times at each end)

h = headway in minutes

The following tables display the inputs and number of trains required. The number of trains required to provide service is a factor in developing costs.

<sup>3</sup> This is the time required to travel around the Bowdoin Loop from Government Center westbound to Government Center eastbound.

**Table 1-5 Comparison of Blue Line Extension Running Times Headways**

<b><i>Existing Blue Line Operations</i></b>		
One way running time - Wonderland to Bowdoin	20.0	minutes
End of line time at Bowdoin Station (existing)	3.0	minutes
One way running time - Bowdoin to Wonderland	21.0	minutes
End of line time at Wonderland Station	10	minutes
Cycle time	54.0	minutes
Headway during AM Peak Period	4.5	minutes
Run-As-Directed Train	1	train
<b>Train requirements</b>	<b>13</b>	<b>peak trains</b>

Alternative 1 assumes the elimination of Bowdoin Station. The net increase in round trip running time for the Blue Line extension from Government Center Station to Charles/MGH Station and back would be approximately 2.5 minutes of additional travel time (assuming the layover at MGH /Charles is 4.0 minutes and the layover at Wonderland is 8.0 minutes) for Alternative 1 as compared to the current operations ending at Bowdoin Station. Therefore, a total of 14 trains/84 cars (running in both directions) would be required to maintain the current 4.5 minute peak headways. (This included one "Run-As-Directed" train to replace trains that experience difficulties during regular service.)

**Table 1-6 Trains required based on Current Blue Line Weekday Headways and Alternative 1**

<b><i>Blue Line Operations with Alternative 1</i></b>		
One way running time - Wonderland to MGH / Charles	22.5	minutes
End of line time at MGH / Charles	4.0	minutes
One way running time - MGH / Charles to Wonderland	23.5	minutes
End of line time at Wonderland Station	8.0	minutes
Cycle time	58.0	minutes
Headway during AM Peak Period	4.5	minutes
Train requirements	12.9	peak trains
Run-As-Directed Train	1	train
Say	<b>14</b>	<b>peak trains</b>

Alternative 2 assumes a stop at a relocated Bowdoin Station. . The net increase in round trip running time for the Blue Line extension from Government Center Station to Charles/MGH Station and back would be over four minutes of additional travel time (assuming the layover at MGH /Charles is 4.0 minutes and the layover at Wonderland is 8.0 minutes) for Alternative 2 as compared to the current ending at Bowdoin Station. Therefore, a total of 15 trains/108 cars (running in both directions) would be required to maintain the current 4.5 minute peak headways. (This included one “Run-As-Directed” train to replace trains that experience difficulties during regular service.)

**Table 1-7      Trains required based on Current Blue Line Weekday Headways and Alternative 2**

***Blue Line Operations with Alternative 2***

One way running time - Wonderland to MGH / Charles	24.1	minutes
End of line time at MGH / Charles	4.0	minutes
One way running time - MGH / Charles to Wonderland	25.1	minutes
End of line time at Wonderland Station	8.0	minutes
Cycle time	61.3	minutes
Headway during AM Peak Period	4.5	minutes
<b>Train requirements</b>	13.6	peak trains
Run-As-Directed Train	1	train
	<b>15</b>	<b>peak trains</b>

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## 1.3 Blue Line Capacity Analysis

It is the needs of weekday rush hours that generally determine the capacity that a transit line must be able to accommodate. While occasional events may trigger unusual ridership spikes, it is the five-days-per-week rush hours that determine the capacity that must be provided to serve the traveling public. In the analysis that follows, the data is shaped by the 2003 Blue Line Passenger Counts conducted by the Central Transportation Planning Staff (CTPS.) These determine the shape of the Blue Line travel demand in terms of riders per hour and direction and are the basis for reviewing the future 2030 demand estimates that CTPS has made for the Red Line – Blue Line Connector Project.

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### 1.3.1 Peak Loadpoint

The location of maximum utilization of a transit line, the station-to-station pair with the highest ridership is known as the peak loadpoint. As noted in the 2003 count report,

“...the heaviest loadings on the Blue Line over the course of the day and during most time intervals within the day occurred between Maverick and Aquarium stations. On the composite count day, westbound trains arriving at Government Center between 6:15 AM and midnight carried a total of 32,625 riders. Of these, 28,288, or 86.7% were on board between Maverick and Aquarium. The maximum hourly volume at that point was 5,152, on trains arriving at Government Center between 8:00 and 9:00 AM. The maximum 15-minute volume was 1,427, on trains arriving at Government Center between 8:45 and 9:00 AM.”

While the report notes that the eastbound trains leaving Government Center carried almost as many passengers, (32,063 between 6:00 AM and 11:45 PM), the maximum hourly volume was only 4,340 on trains leaving Government Center between 4:30 and 5:30 PM, and the maximum peak 15-minute volume was only 1,141 on trains leaving Government Center between 4:30 and 4:45 PM. These volumes are 84.2 and 80 percent of their respective AM volumes. Thus, from a capacity standpoint, the AM peak period governs the capacity requirements of the Blue Line service. Further, within that peak hour, the 15-minute “peak of the peak” requires 27.7 percent of the hourly capacity within approximately 25 percent of the hour’s total demand.

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### 1.3.2 Loading Standard

The MBTA has updated its Service Delivery Policy document effective January 14, 2009. Its stated purpose is “to ensure that the MBTA provides quality transit services that meet the needs of the riding public” and that also are consistent with the MBTA’s enabling legislation and other external mandates.

Vehicle Load Standards are included in the *Service Delivery Policy* document. Their purpose is to define the levels of crowding that are acceptable by time period and mode (with some different standards for vehicles within a mode where applicable. In the case of heavy rail, separate standards are promulgated for the Blue, Orange, Red, and Green lines and even for the Number 1 and 2 car fleets versus the Number 3 fleet on the Red line.) It should be understood that the load standards represent average maximum loads over the particular time period, expressed on a per-car basis. This means that, depending on scheduling constraints and passenger peaking characteristics (including the different loadings between individual cars in a train), some individual trips or vehicles may exceed the values expressed in the standards even though the average load will comply.

In the case of the Blue Line, the Service Delivery Policy stipulates a Peak Maximum Load of 95 passengers per car for the 45-seat Number 4 cars that then were its fleet; this amounts to a Peak Load Standard of 225 percent, the ratio of maximum passengers to seats. However, since the issuance of this document, replacement of the Number 4 cars with 37-seat Number 5 cars has largely, if not completely, taken place. Given that the length and width of both fleets is the same, it is assumed that the 95-passenger-per-car capacity is effectively unchanged, except that there is slightly more circulating room within the newer vehicles.

Along with the fleet replacement, the Blue Line also has gone over to operating 6-car trains rather than 4-car trains. This means that each train has a capacity of 570 passengers on average, even if each car does not carry exactly 95 passengers.

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### 1.3.3 Capacity Analysis

The ridership projections from CTPS are all expressed in terms of total weekday trips and apparently do not contain details for either the AM or PM rush periods and, more particularly, the peak 15-minute periods. Accordingly, it is necessary to relate these future projections to the 2003 counts which do present this data in order to determine the required level of capacity that the Blue Line will have to support.

**No Build Alternative** – Based on the projections from the travel demand analysis provided by CTPS, the average weekday ridership on the Blue Line would grow from 64,500 in 2008 to 73,000 in 2030. This is an increase of 12.85 percent over the

64,788 weekday ridership from the 2003 counts. Using the 2003 count value of 1,427 in the AM peak 15 minutes as a basis, the No-Build alternative is projected to carry 1,610 passengers in the AM peak (12.85 percent more riders) between Maverick and Government Center stations.

**Alternative 1** – Blue Line extension to Charles/MGH Station with the elimination of Bowdoin Station – This alternative is projected to have a weekday ridership of 77,200 in 2030. This is an increase of 19.34 percent over the 2003 level. Applying this growth percentage to the 2003 AM peak 15 minute ridership results in a peak 15-minute ridership of 1,703 in the AM rush period.

**Alternative 2** – Blue Line extension to Charles/MGH Station with the relocation of Bowdoin Station – Ridership on weekdays is projected to become 77,400 by 2030. Compared to the 2003 counts, this is an increase of 19.65 percent over the 2003 volume. Using the same technique, the AM peak 15-minute ridership for the Build 2 alternative would be 1,707 riders.

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#### **1.3.4 Capacity Analysis Conclusion**

According to the MBTA Headway Report effective 6/20/09, there are 14 westbound Blue Line trains arriving at Government Center between 7:59 and 8:58 AM. During the 14 minutes from 8:44 to 8:58 AM there are 4 westbound trains arriving there. This provides a 15-minute passenger capacity of 2,280. This is some 34 percent greater than the projected demand in 2030. Therefore, it appears that the current peak period schedule of 6-car trains will provide sufficient capacity to carry the projected 2030 ridership consistent with MBTA service standards for the Blue Line.



# **APPENDIX**

## **One-Way Running Time Calculations for the Blue Line Extension**

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# Red Line/Blue Line Connector Project

## Blue Line Operational Analysis

RED LINE - BLUE LINE CONNECTOR STUDY													
Charles/MGH Station to Government Center Station Running Time Calculation													
Based on Scheme MT-2													
Station	Chaining Point	Station Spacing (feet)	Speed Limit (mph)	Speed Change - to - Cruise:			Cruising:		Total Run Time (sec.)	Dwell Time (sec.)	Schedule Adjustment Factor - %	Schedule Time (minutes)	Cumulative Schedule Time (minutes)
				Speed Range (mph)	Distance (feet)	Time (sec.)	Distance (feet)	Time (sec.)					
<b>Charles/MGH Station</b>	0+35												
station	3+50	315	10	0 - 10	27	3.7	288	19.6					
crossover	10+00	650	15	10 to 15	35	1.9	615	28.0					
	19+00	900	30	15-30-20	313.46	9.4	586.54	13.3					
	24+50	550	20	20-15	52.82	1.8	497.18	16.9					
<b>Government Center Station</b>	27+76.47	326	15	15-0	57	5.2	269	12.2	112.1	0	20%	2.24	2.24
<b>Notes:</b>													
1. Running time assumed to be the same in AM and PM and in each direction at this level of alignment detail.													
2. Schedule Adjustment Factor provides allowance for vehicle and operator vagaries as well as lack of specific alignment information.													
3. Does not include dwell time at Government Center.													
4. Crossover length includes one train length (300 ft.) of speed restriction.													

# Red Line/Blue Line Connector Project

## Blue Line Operational Analysis

RED LINE - BLUE LINE CONNECTOR STUDY													
Charles/MGH Station to Government Center Station Running Time Calculation													
Based on Scheme MT-3													
Station	Chaining Point	Station Spacing (feet)	Speed Limit (mph)	Speed Change - to - Cruise:			Cruising:		Total Run Time (sec.)	Dwell Time (sec.)	Schedule Adjustment Factor - %	Schedule Time (minutes)	Cumulative Schedule Time (minutes)
				Speed Range (mph)	Distance (feet)	Time (sec.)	Distance (feet)	Time (sec.)					
Charles/MGH Station	0+35												
station	3+55	320	10	0 - 10	27	3.7	293.00	20.0					
crossover	9+63	608	15	10 - 15	35.00	1.9	573.00	26.0					
		657	20	15-20-0	155.10	17.4	501.90	17.1					
									86.1	0	20%	1.72	1.72
Bowdoin Station (New)	13+00												
		1,156	20	0-20-0	217.10	15	939.37	32.0					
									47.0	20	20%	1.34	3.06
Government Center Station	27+76.47												
Notes:													
1. Running time assumed to be the same in AM and PM and in each direction at this level of alignment detail.													
2. Schedule Adjustment Factor provides allowance for vehicle and operator vagaries as well as lack of specific alignment information.													
3. Does not include dwell time at Government Center.													
4. Crossover length includes one train length of speed restriction.													